

1    CLAIMS

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3    1. A plug for controlling fluid flow in a well bore, the  
4    plug comprising a substantially cylindrical body  
5    adapted for location on a work string, the body  
6    including a bore through a portion thereof and one or  
7    more radial ports for passage of fluid from the bore  
8    to an outer surface of the body, an actuating member  
9    moveable relative to the body so as to cover the one  
10   or more radial ports in a first position and uncover  
11   the one or more radial ports in a second position  
12   wherein movement of the actuating member is  
13   controlled by an actuating mechanism, the mechanism  
14   being operable under pressure in the well bore to set  
15   the plug in a first natural state wherein the  
16   actuating member is in the first position for a  
17   pressure under a predetermined pressure range; a  
18   second closed state wherein the actuating member is  
19   locked in the first position regardless of the  
20   pressure; and a third open state wherein the  
21   actuating member is moved to the second position on  
22   increasing the pressure to the predetermined pressure  
23   range and holding the pressure in the range for a  
24   predetermined time.

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26    2. A plug as claimed in Claim 1 wherein the actuating  
27   mechanism comprises one or more pistons operated on  
28   by the applied pressure.

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30    3. A plug as claimed in Claim 2 wherein the actuating  
31   mechanism comprises first and second pistons; the  
32   first piston including a damping element for delaying  
33   movement of the first piston relative to the second

1       piston under the applied pressure; the second piston  
2       acting on a retaining element; the retaining element  
3       adapted to hold the second piston in an intermediate  
4       position when the applied pressure is within the  
5       predetermined range and allow movement of the first  
6       piston to a final position; the retaining element  
7       allowing the second piston to move to a secondary  
8       position when the applied pressure is above the  
9       predetermined range; a locking element which prevents  
10      movement of the first piston when the second piston  
11      is in the secondary position; and a securing element  
12      for retaining the actuating member in the first  
13      position until released by virtue of the first piston  
14      reaching the final position, whereby the actuating  
15      member moves to the second position and opens the  
16      plug.

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18     4. A plug as claimed in Claim 3 wherein the damping  
19      element is a fluid metering device.

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21     5. A plug as claimed in Claim 3 or Claim 4 wherein the  
22      retaining element is a collet.

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24     6. A plug as claimed in Claim 5 wherein the locking  
25      element is a sleeve such that the retaining element  
26      and the locking element engage to control movement of  
27      the pistons.

28

29     7. A plug as claimed in Claim 1 wherein the actuating  
30      mechanism may comprises a pressure sensor located in  
31      the bore to measure the applied pressure, a processor  
32      programmed to control a motor in response to the  
33      pressure wherein operation of the motor causes the

1 required relative movement between the actuating  
2 member and the body.

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4 8. A plug as claimed in Claim 7 wherein the mechanism  
5 also comprises a securing element for retaining the  
6 actuating member in the first position.

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8 9. A plug as claimed in any preceding Claim wherein the  
9 actuating member is a sleeve.

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11 10. A plug as claimed in Claim 9 wherein the securing  
12 element is one or more locking keys which engage with  
13 the sleeve.

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15 11. A plug as claimed in any preceding Claim wherein the  
16 predetermined range for the pressure is approximately  
17 1200 to 1800 psi.

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19 12. An actuating mechanism for operating a tool used in a  
20 well bore, the mechanism comprising first and second  
21 pistons; the first piston including a damping element  
22 for delaying movement of the first piston relative to  
23 the second piston under an applied pressure; the  
24 second piston acting on a retaining element; the  
25 retaining element adapted to hold the second piston  
26 in an intermediate position when the applied pressure  
27 is within a predetermined range and allow movement of  
28 the first piston to a final position; the retaining  
29 element allowing the second piston to move to a  
30 secondary position when the applied pressure is above  
31 the predetermined range; a locking element which  
32 prevents movement of the first piston when the second  
33 piston is in the secondary position; an actuating

1 member whose movement operates the tool; and a  
2 securing element for retaining the actuating member  
3 in a first position until released by virtue of the  
4 first piston reaching the final position, whereby the  
5 actuating member moves to a second position and  
6 operates the tool.

7

8 13. An actuating mechanism as claimed in Claim 12 wherein  
9 the first and second pistons include substantially  
10 conical drive faces with apexes directed towards the  
11 applied pressure.

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13 14. An actuating mechanism as claimed in Claim 12 or  
14 Claim 13 wherein the damping element is a fluid  
15 metering device.

16

17 15. An actuating mechanism as claimed in Claim 14 wherein  
18 the fluid metering device comprises a fluid filled  
19 chamber through which the first piston passes and a  
20 portion of the first piston includes a restrictor to  
21 regulate fluid flow between upper and lower  
22 compartments of the chamber.

23

24 16. An actuating mechanism as claimed in Claim 15 wherein  
25 a pressure balance piston is located in the chamber,  
26 around the first piston so as to control the size of  
27 the chamber in order to compensate for thermal  
28 effects and pressure differences between inside and  
29 outside the chamber.

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31 17. An actuating mechanism as claimed in any one of  
32 Claims 12 to 16 wherein the retaining element is a  
33 spring.

1 18. An actuating mechanism as claimed in Claim 17 wherein  
2 retaining element is a collet.

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4 19. An actuating mechanism as claimed in any one of  
5 Claims 12 to 18 wherein the locking element is a  
6 sleeve such that the retaining element and the  
7 locking element engage to control movement of the  
8 pistons.

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10 20. An actuating mechanism as claimed in any one of  
11 Claims 12 to 19 wherein the actuating member is a  
12 sleeve and the securing element is one or more  
13 locking keys which engage with the sleeve.

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15 21. A method of controlling fluid flow in a well bore,  
16 the method comprising the steps:  
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18 (a) locating a plug in a well bore, the plug  
19 including an actuating mechanism to operate the  
20 plug;

21 (b) increasing pressure from a surface of the well  
22 bore to within a predetermined range; and

23 (c) keeping the pressure within the predetermined  
24 range over sufficient time to cause the actuating  
25 mechanism to move and open the plug.

26

27 22. A method of controlling fluid flow in a well bore as  
28 claimed in Claim 21 wherein the plug is as claimed in  
29 any one of Claims 1 to 11.

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31 23. A method of controlling fluid flow in a well bore as  
32 claimed in Claim 21 or Claim 22 wherein the method

1       includes the step of applying pressure above the  
2       predetermined range.

3

4       24. A method of controlling fluid flow in a well bore as  
5       claimed in any one of Claims 21 to 23 wherein the  
6       method includes the step of locking the plug in a  
7       closed position in the event that the pressure  
8       exceeds the predetermined range.

9

10      25. A method of controlling fluid flow in a well bore as  
11       claimed in any one of Claims 21 to 24 wherein the  
12       method includes the step of performing a pressure  
13       test above the plug.

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15      26. A method of controlling fluid flow in a well bore as  
16       claimed in any one of Claims 21 to 25 wherein the  
17       method includes the step of bringing the pressure  
18       back down to below the predetermined range to then  
19       perform steps (b) and (c) to open the plug.

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